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FINAL REPORT

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MATURATION OF CORTICAL EVOKED POTENTIALS

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A B S T R A C T

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Experimental procedures for eliciting cortical electrical responses to sensory stimuli in young infants and children have been devised, adequate recording and data processing techniques using a general purpose, digital computer have been developed. The population being studied covers an age range from infant to young adult. Although for the most part normal children have been studied, recordings have also been obtained from a group of children with various sensory and neurologic disorders. A recording unit has been placed in the newborn nursery of Walter Reed General Hospital and EEG records on 15 normal infants from forty five minutes of age to 4 days have been collected.

Evoked responses to both lights and sounds have been obtained from the youngest infants studied. The latencies of the evoked responses decrease with increasing age and the form of the wave changes with age. Amplitudes and latencies of the evoked responses and the response waveforms differ in sleeping and waking states. Latencies usually decrease and amplitudes increase as the stimuli intensity increases. Patterns from children with severe neurologic and sensory deficit differ from those obtained from normal children. Before more conclusive statements can be made, however, additional data must be obtained.

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I. INTRODUCTION

The current investigative effort is aimed at obtaining information on the electrical responsiveness of the auditory and visual systems in the immature human brain. Electroencephalographic patterns are changing and developing until approximately adolescence; it was therefore proposed that subjects representing an age range from the neonatal period to adolescence be studied to secure both cross-sectional and longitudinal data. During the past year efforts have been directed toward (1) the refinement of experimental procedures and development of suitable recording techniques, (2) the administration of pertinent neurological and psychological tests, (3) the analysis of the evoked cortical responses.

II. PROGRESS

(1) Refinement of experimental procedures and development of suitable recording techniques: The main endeavor has been to develop effective techniques for eliciting responses from the auditory and visual areas of the cortex and to devise a suitable means of recording and processing the obtained data. Scalp electrodes are applied according to the International Electrode Placement System to obtain standard bipolar recordings from frontal, central, parietal, temporal, and occipital areas. Stimulation is delivered to the subjects in a dark, electrically shielded room where environmental variables can be brought under control. Repetitive stimulation (one per second) from a stimulus-subject distance of one meter has evoked both auditory and visual responses in infants and children. Three sets of stimuli,

each composed of 250 clicks, are used. Each set is attenuated 20 db. from the preceding set. After an electroencephalogram without sensory stimulation is recorded, the presentation of visual stimuli is undertaken. A flash discharge photostimulator subtending a visual angle of one degree is used to produce the visual stimuli. Five sets, each composed of 250 flashes, are used. The sets are presented in an ascending order of luminance. Blue and orange filters are used as well as white light. In some subjects an electroretinogram is recorded, using electrodes at the external and medial canthi of the eye or under the lower lid. In one subject a contact lens electrode was used.

Two recording set ups are in operation, one in the newborn nursery of Walter Reed General Hospital, the other for the older subjects, at the Forest Glen Annex of Walter Reed. Effort has been expended to make the two setups as nearly alike as possible.

The clicks are presented prior to the flashes, thus allowing thirty minutes for dark adaptation time. The evoked responses between each bipolar location on the cortex are amplified by a maximum factor of 10^5 . The cortical electrical responses are then recorded on a multichannel, Ampex, Fii, magnetic tape recorder and are simultaneously monitored on a modified polygraph.

The evoked cortical response is small relative to the high voltage background electroencephalographic activity which, together with noise, obscures it. Averaging increases the signal to noise ratio and effectively isolates the evoked response. A general purpose, digital computer (the PB 250) has expedited the averaging procedure. Computer programs applicable to the present study have been designed for averaging responses as well as for measuring amplitudes and latencies of

numerous features of the average response. The data, which is recorded on magnetic tape, may be processed concurrently with the recording or at a later date.

(2) The neurological examination and the administration of psychological tests: A brief neurological examination is performed on all subjects and a psychological test is administered to subjects older than two months of age. The purpose of assessment is to determine the intellectual functioning level concurrent with the evoked response findings and also to aid in classifying the subject population into normal and abnormal groups. A medical examination which evaluates neurological and physical development has usually been corroborative of the psychological findings.

The Cattell Infant Intelligence Scale has been administered to subjects between two months and two years chronological age; the Stanford-Binet Intelligence Scale to subjects between two and six years chronological age; the Wechsler Intelligence Scale for Children to subjects between seven and fifteen years chronological age. The Vineland Social Maturity Scale and the Goodenough Draw-A-Man Test occasionally have been used for qualitative purposes. The mean IQ for the normal population was found to be 110.5, and the mean age for this group was 3.74 years.

A protocol for recording infant behavioral responses and visual and auditory reflex responses for neonatal subjects is currently being tested and modified.

III. THE EVOKED RESPONSE

Fifteen EEGs with repetitive light and sound stimulation have been done on 9 different normal neonates. 68 EEGs on 51 older children and adults have been done. Evoked responses to both lights and sounds have been present in the youngest infants studied. 13 records on children with various neurologic disorders and sensory deficits have been performed. In deaf or blind children and in children with severe brain damage and apparent "cortical blindness and deafness", the responses are abnormal or not distinguishable.

The response waveform is dependent upon a number of variables. In general, with more intense stimulation, the latency appears shorter, amplitude increases, and the response waveform becomes more complex. Sleeping and waking patterns show differences in amplitude, latency, and frequency. There have been indications of a decrease in EEG response latencies as the child gets older.

IV. SIGNIFICANCE

The study of the electrophysiological responses of the immature brain to sensory stimuli and the mapping of the development of these responses will give, it is hoped, some indications as to the way in which brain function matures. The decrease in latency, the increase in complexity of the wave forms, and the apparently greater influence of stage of sleep on the response in older subjects reflects this maturation. It is hoped that correlations of the electrophysiologic responses with other parameters of maturation in both normal and

abnormal subjects can be made as the study progresses.

The technique holds some promise as a diagnostic tool in the study of sensory abnormality and brain dysfunction in the very young.

V. SUMMARY

Experimental procedures for evoking cortical responses in the immature brain have been initiated. Recording techniques and data processing have been facilitated by a general purpose, digital computer. Programs for averaging evoked response waveforms and for measuring the amplitudes and latencies of their principal components have been written. Neurological and psychological examinations make it possible to classify subjects into normal and abnormal groups and help describe auditory and visual behavior at different age levels. It is hoped that eventually data from these measures can be correlated with electroencephalographic development. Analysis of the response waveforms obtained to date have suggested that there are developmental changes of the evoked response which might be correlated with other maturational parameters.

VI. Publications to date: none

VII. Graduate Students: none